

April 30, 1966

To:

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Gentlemen:

Enclosed please find the Nineteenth Quarterly Report for NASA Contract NAS 8-2504. This is for the quarter ending March 31, 1966.

Sincerely,

John C. Heine

John C. Heine

JCH:kmc

Enclosure

ESTABLISHMENT OF GUIDELINES FOR RANDOM AND
SINUSOIDAL VIBRATION CORRELATION
NINETEENTH QUARTERLY REPORT

March 31, 1966

Both of the originally proposed¹ experiments have been completed this past quarter. The material damping of three engineering alloys, 1080 steel, 416 stainless steel, and 2024-T4 aluminum has been studied by determining the resonant responses of simple structural elements fabricated from these alloys.

The structural elements were in the form of

- (i) torsional pendulums
- and (ii) cantilever beams.

Photographs of both experimental apparatuses have been presented in previous quarterly reports.^{2,3} Specimens were fabricated from cold-drawn bar stock and were not heat treated in any way.

A typical test consisted of determining the amplification factor at resonance of a specimen at a series of stresses of up to 80% of the material proportional limit. The mechanical amplification at resonance Q and the specimen damping capacity g_s (the ratio of the total energy dissipated per cycle in the specimen to 2π times the peak strain energy of the specimen

¹"Study of Material Damping Caused by Uniaxial and Biaxial Vibration Stress Systems," Proposal for Extension for NASA contract NAS 8-2504.

²Eighteenth Quarterly Report for NASA contract NAS 8-2504.

³Nineteenth Quarterly Report for NASA contract NAS 8-2504.

in the cycle) are related by the equation

$$\frac{1}{Q} = g_s \quad (1)$$

In the remainder of this report, the term "damping" will refer to the magnitude of the specimen damping capacity.

The frequency and stress ranges in which each specimen configuration was tested and a discussion of the relationship between damping and stress and frequency are listed for each material below.

1018 STEEL

	FREQUENCY RANGE (cps)	STRESS RANGE (psi)
Bending Test	25 - 300	5,000 - 40,000
Torsion Test	60 - 400	2,500 - 20,000

DISCUSSION: (1) Bending test.- Both the damping and the relationship between damping and stress for this material was a function of frequency. Damping for low frequency tests, when transverse thermal current damping⁴ would be a maximum, was substantially independent of stress amplitude and a function of frequency. A test run at a frequency at which thermal current damping was small, showed a marked stress dependence.

(2) Torsion Test.- Damping was stress dependant but frequency independent.

⁴See, for example, Zener, C. M., "Elasticity and Anelasticity of Metals" Chicago; University of Chicago Press, 1948.

416 STAINLESS STEEL

	FREQUENCY RANGE (cps)	STRESS RANGE (psi)
Bending Test	25 - 160	5,000 - 40,000
Torsion Test	60 - 200	2,500 - 20,000

DISCUSSION: (1) Bending Test.- Damping was approximately dependent on stress to the first power throughout the stress range and was independent of frequency.

(2) Torsion Test.- The stress dependence of damping in torsion was somewhat more complicated than that in bending. As stress was increased, damping first increased linearly with stress, then attained a maximum value and began to decrease. This effect may be shown to be due to the fact that 416 stainless steel is a ferromagnetic material and hence is subject to magnetostrictive damping.⁵ A damping peak with stress can in fact be predicted in a qualitative sense for ferromagnetic materials. No frequency dependence of this material in torsion was observed.

2024-T4 ALUMINUM

	FREQUENCY RANGE (cps)	STRESS RANGE (psi)
Bending Test	25 - 1000	5,000 - 35,000
Torsion Test	60 - 1000	2,000 - 17,500

DISCUSSION: (1) Bending Test.- Damping was highly frequency dependent and not at all amplitude dependent. Data was well correlated by the theory of transverse thermal currents.⁴

(2) Torsion Test.- Damping in torsion was generally one order of magnitude below that in tension at any frequency. The damping displayed approximately an inverse relationship to frequency and a high stress dependence.

⁵ See, for example, Cochardt, A., "Magnetomechanical Damping" Chapter II in book Magnetic Properties of Metals and Alloys, Am. Soc. for Metals, 1959

A final report is in preparation which details (1) possible mechanisms for the stress and frequency dependence of damping data for these alloys, (2) the experimental apparatus and test method used, and (3) correlation of bending and torsion data with possible applications for the computation of energy losses due to material damping in a structural member under a general state of biaxial stress. It is expected that this report will be completed by May 15, 1966.